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A Critical Analysis of the Suitability of Cloud Technology for Healthcare Services Delivery in Nigeria

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Abstract: Across the nations of the world, governments and institutions face myriad of issues in their search for an improved healthcare service delivery to their citizens and employees. In the recent past, many healthcare organizations adopted a centralized system in which they had to acquire and maintain all the requisite hardware, software and relevant staff regardless of whether or not these resources were used at full capacity or not and often with the attendant insecurity and cost. The challenges faced by the healthcare industry can perhaps be better understood when it comes to managing vast number of medical records, integrating social and healthcare information and developing the infrastructure to interconnect many. With these challenges, the question whether cloud technology can be applied in healthcare delivery arises. This paper presented a critical study to discuss the suitability of the adoption of cloud computing in healthcare service delivery in Nigeria. we used data from secondary sources to discover that healthcare system and cloud computing technologies have been successfully been merged and presented in some countries where e-Health care system has succeeded. There is therefore no doubt that the adoption of cloud based healthcare will offer relieve from the challenges faced by different stakeholders in the healthcare industry and provide more efficient healthcare service to all citizens of the Nigerian nation.

Key words: Cloud Computing · E-Health · Healthcare Management · ICT · Suitability

INTRODUCTION

The deployment of information and communication technology has impacted greatly in the development and advancement of all sectors of our society. It has always been intertwined with human development for even every small economic or social growth. Information and communication technology (ICT) and web services have a major impact on the quality of services and peoples' lifestyle. The implementation of ICT in the health sector, popularly known as e-Health, is emerging as one of the most rapidly growing areas in healthcare today [1]. It has paved way for a new area of research among doctors, scientists and researchers who try to develop efficient and accurate technologies for dealing with the health problems while the policy makers look at it from the view point of providing affordable healthcare to everyone. At the same time it also helps in imparting knowledge and creating interest among common people. To achieve national and global health appropriate use of ICT should be applied which can bridge the digital and health gap. The technological innovations lead to new applications for disseminating healthcare information to diverse audiences using innovative interoperable design. These applications are simple, easy to use, engaging and capable of delivering relevant information for primary healthcare to diverse users.

According to Alam and Ali [2] e-Health is the use of information technologies across health-related functions and activities. The adoption of e-Health has several benefits to physicians, patients, management and other departments [3]. Cloud technologies can be implemented in healthcare as a way for maintaining or managing patient information, monitoring patients' progress, managing diseases and disease surveillance more efficiently and effectively, while helping professionals to collaborate with

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colleagues at different locations [4]. Cloud computing adoption makes it much easier for patients and healthcare institutions to locate and keep track of their own medical history while facilitating medical information resource sharing among healthcare providers. Cloud allows users or organizations to have the right to access medical records online, to engage their providers via digital channels and to share their records across teams of healthcare professionals [5]. Cloud computing also helps to provide rapid access to the electronic medical records of patients especially in Emergency situations by providing important information about a patient's medical history and current description of medications [6]. Current trends aim towards accessing information anytime and anywhere. This can be achieved by moving healthcare information to the cloud. Most healthcare institutions are now shifting the burden of managing and maintaining complex HIT to the Cloud service providers [7]. Cloud adoption also provides the ability to exchange data between disparate and separate systems. Also Cloud computing can be used in educating healthcare professionals in providing access to medical knowledge, applications and literature, while serving as a source for public and formal education for health [8]. Also, stakeholders in healthcare including Doctors, Nurses and Physicians can gain access to private cloud through the cloud infrastructure of a particular Cloud Service Provider (CSP) and are able to view information such as the medical history of their patients before attending to them [9]

Brief Overview of Cloud Computing: The use of Internet and other information and communication technologies have become part of our everyday life. Any information is available anywhere in the world at any time just by the click of a button once the user has access to an internet connection. Today a lot of people use their mail online through webmail clients, write and share collaborative documents using web browsers, create virtual albums to upload the photos of their memorable events. These users run applications and store data in servers located in remote places and not in their own computers through the Internet. The service could be something as simple as entering information in a web browser. This could be the only thing a user needs to begin to use services that reside in a remote server and lets him/her share private and confidential information, or using computing cycles of a pile of servers that he/she will never see with his/her own eyes.

Definition of Cloud Computing: The term Cloud Computing since introduced has been defined by various authors in different ways. We present some of these definitions below. Cloud Computing describes applications that are extended to be accessible through the internet and for this purpose large data centers and powerful servers are used to host the web applications and web services [10].

According to Bouamrane and Mair [11] the IT encyclopedia *whatis.com* defines cloud computing as a general term for anything that involves delivering hosted services over the Internet. According to the encyclopedia a cloud service has three distinct characteristics that differentiate it from traditional hosting. It is sold on demand, typically by the minute or the hour; it is elastic - a user can have as much or as little of a service as they want at any given time; and the service is fully managed by the provider (The consumer needs nothing but a personal computer and Internet access).

The most frequently referenced definition is the one given by National Standards for information Technology (NIST). According to Catteddu and Hogben [12] NIST defined Cloud computing as a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. From the definitions given above, we can state that cloud computing is a computational paradigm based on consumption of resources, applications, hardware or computation, offered by internet and consumed under demand. These services are public or private, for free or for price and have service level agreements that regulate their use.

Cloud Deployment Models: There are basically four models of cloud computing deployment as described in the following subsections and shown in Figure 1.

Public Cloud: Public cloud (Also known as external cloud), is the traditional way, where services are provided by a third part via Internet and they are visible to everybody (It doesn't mean that they have to be free). So in the cloud it's the information of lots of users but they can't access of course to the information of the others [13]. A public cloud encompasses the traditional concept of cloud computing, having the opportunity to use computing resources from anywhere in the world.

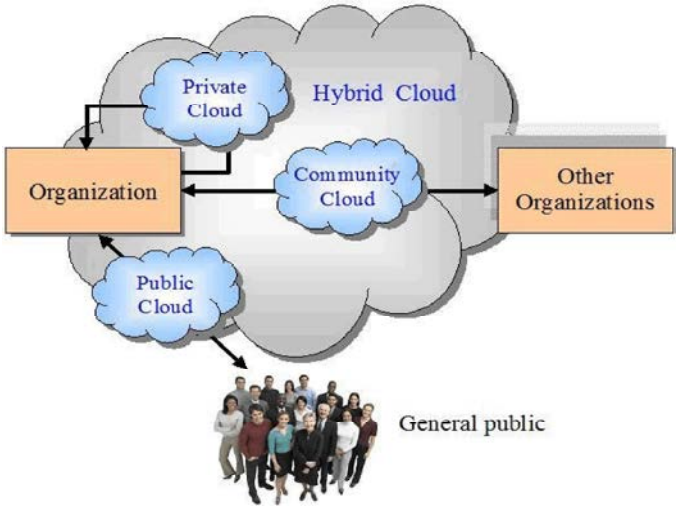

Fig. 1: The cloud computing deployment models [21].

The clouds can be used in a so-called pay-per-use manner, meaning that just the resources that are being used will be paid by transaction fees [14, 15].

Private Cloud: This cloud consists on the hosting of private applications, storage, or computation in the same company emulating a cloud in Internet but only for private use (Private networks). The coast of infrastructure and maintenance of it is the same that having it in normal way but the scalability and the sharing of the coasts is better [16]. Private clouds are normally datacenters that are used in a private network and can therefore restrict the unwanted public to access the data that is used by the company. It is obvious that this way has a more secure background than the traditional public clouds. However, managers still have to worry about the purchase, building and maintenance of the system [17, 18]

Hybrid Cloud: It‘s a combination of public and private cloud. An organization can have a part of their services in its own infrastructure but also in public cloud. Or can use the public just when have peaks of usage. It‘s a good option when you want to have your data or application in local and don‘t want to invest too much in infrastructure [19]. As the name already reveals, a hybrid cloud is a mixture of both a private and public cloud. This can involve work load being processed by an enterprise data center while other activities are provided by the public cloud [20].

Community Cloud: The cloud infrastructure is shared by several organizations with common concerns (eg, mission, security requirements, policy and compliance considerations). For example, the Google GovCloud provides the Los Angeles City Council with a segregated data environment to store its applications and data that are accessible only to the city’s agencies.

Services and Architectures of Cloud Computing: Cloud Computing encompasses different types of services. These are classes of technology capabilities that are offered as a service [22]. According to Hossain [23] cloud computing offer the following services:

Infrastructure as a Service (IaaS): This comprises services to allow its consumers to request computational, storage and communication resources on-demand, thus enabling the so called “Pay-per-use” paradigm whereby consumers can pay for exactly the amount of resource they use (Like for electricity or water). The consumers can use the provided resources to deploy and run arbitrary software; however, the management and control of the underlying cloud infrastructure is possible only by the provider. Instead of investing in their own corporate server or network infrastructure, companies are able to purchase those resources on a rental basis and use it on demand rather than having their own resources locally. The providers are taking care of the servers, storage and network settings, while the client has virtual instances of that [24, 25]. Examples of these services are Google Drive, 3 Tera, DropBox, Amazon EC2, APPNexus, RackSpace and GoGrid.

Platform as a Service (PaaS): This comprises high-level services providing an independent platform to manage software infrastructures, where consumers

(i.e., developers) can build and deploy particular classes of applications using programming languages, libraries and tools supported by the provider. Usually, consumers don't manage or control the underlying infrastructure (Such as servers, network, storage, or operating systems), which can only be accessed by means of the high-level services provided by the provider. Examples of these services include Google App engine, AppStore and Microsoft Azure.

Software as a Service (SaaS): These services are applications over Internet. They comprise specific end-user applications running on a cloud infrastructure. Such applications are delivered to consumer as a network service (Accessible from various client devices, ranging from desktop computers to smartphones), thus eliminating the need to install and run the application on the consumer's own computers and simplifying maintenance and support. Consumers don't manage or control the underlying infrastructure and application platform; only limited user-specific application configurations are possible. Examples are Google Docs, Gmail, Google App, Salesforce.com, Microsoft Office 365 and acrobat.com.

Overview of e-Health Care: Health care is one of the fundamental human rights in any nation. People have to go to the public health care institutions or private medical centres for medical checkup and treatment. Again a patient may go to a different doctor or hospital for different diseases or even for the same disease. Each time the patient goes to a different place, he has to give his personal details such as name, sex, name, age, gender, address, etc. which is cumbersome and sometimes prone to errors. Some hospitals have a system to maintain patients' medical records but it is limited within the treatment facilitated by those hospitals only or some cases different departments within the same hospital. Most of the cases the medical record is maintained in paper format which can be easily misplaced lost or exposed to unauthorized parties. Another important issue is checking the authenticity of the medical staff like doctors, nurses, pathologists etc. It is important for hospitals to verify the background of the medical staff while recruiting to avoid fraud cases. It is also important for the patients to check the profile of whom he will get the treatment. Sometimes medical staff is blacklisted due to his mistreatment of the patient. This information is also crucial for both medical centers and patients to make the health care system a reliable one [26]. Adoption of Information and Communication Technology (ICT) with the health care system is a demand of this day for increasing the efficiency of medical information management [27]. A broad range of e-Health applications have emerged to enable patient, nurse, doctor and administrator to efficiently access relevant information, enhance the quality of patient care and reduce health care errors [28-30]. Since e-Health services are usually cloud enabled where ubiquitous access to healthcare data are considered essential for effective treatment, electronic records of the patients frequently need to be exchanged among different health care institutions [31]. So the system is exposed to all kinds of security threats. Again electronic records are more vulnerable than paper based documents.

Cloud Technology for Healthcare Management: The challenges faced by the healthcare industry can perhaps be better understood when it comes to managing vast number of medical records, incorporating social and healthcare information and developing the infrastructure to interconnect many hospitals for efficient health care delivery. With these challenges in mind, the benefits of cloud technology can be applied in health care delivery in order to resolve the challenges. Cloud computing is changing the way doctors, nurses, clinics and hospitals deliver quality and economical services to their patients. Today, the use of cloud technology include its ability to efficiently process and deliver data in a collaborative fashion and analysing data into meaningful information to offer relieve from the challenges in the health care industry. The following highlight the reasons cloud technology is seen as being suitability for adoption in healthcare management.

Healthcare Management information System: Healthcare industry has started using management information systems to streamline the information flow within and outside the organization [32]. Physicians use the system to provide better patient care; customers use it for querying service; administrators use this to manage the human resource, billing and finance; top management use this system for decision making and forecasting purpose [33]. These are the proprietary systems which contain the mission critical data about the organization. Due to the confidentiality of the information, developers can use PaaS cloud to develop, test and deploy this system. PaaS ensure the rapid collaborative development, cross-platform compatibility and integration of the system with other legacy systems.

Reduction of Healthcare Operational Expenses and Cost: By using cloud services, healthcare organisations only need to pay for what they use, such as storage, applications and infrastructure service. Also another key benefit of the cloud technology offers to flexibility the healthcare industry as cloud technology providers can scale resources up or down as needed. The cloud also provides real-time and remote access to applications and resources in a way that's easy to use [34]. This real time access to resources is very important in health care delivery considering the fact that lives may be involved at any given time. Healthcare providers seek innovative health IT solutions that allow them to address the increased focus on both resource efficiency and value-based healthcare, delivering better care at lower costs. Cloud computing and Cloud-based healthcare systems are comparable and offer a model that deliver a range of information and communication technology services with opportunities for cost saving and innovation [35]. As a result the adoption of Cloud technology in the healthcare sector has the potential to support the delivery of integrated healthcare at a lower cost and make healthcare operations even more convenient.

Clouds for Drug Discovery: Drug discovery is a process of discovering new medicines while ensuring its efficacy and reducing any resultant side effects. Across the globe, Molplex is helping scientists reduce the time and cost of screening large data sets of chemical compounds to identify potential drugs. Researchers are using automated tools in the cloud to increase the rate of success in drug discovery as they work to treat tropical diseases such as malaria, tuberculosis and dengue fever. Researchers from Molplex, a small drug discovery company; Newcastle University; and Microsoft Research Connections work together to help scientists across the globe deliver new medicines more quickly and at lower cost. This joint venture called Clouds Against Disease, draws its power from cloud computing and it offers high-quality drug discovery services based on a new molecular discovery platform [36].

Disaster Recovery: Mullner and Chung [37] listed the applications that are suitable for the cloud. The applications included applications that need to apply disaster recovery and services whose data need to be back up in a secured environment. Heath care service can no doubt benefit from cloud technology as medical records can easily be stored be in a secured cloud environment and the medical data recovered in case of occurrence of disaster since the medical are clouds are not physical resident at the site of where the disaster occurred but are safely secured in the servers of the cloud provider hosting the institutions' medical records platform.

Efficient Healthcare Delivery: Cloud computing in healthcare provides the technology driven facilities to integrate healthcare services that brings significant benefits to the sector. Despite some challenges, cloud computing in healthcare provides improvement in terms of service delivery and grant quick and timely access to health care resources to patients in as witnessed in Ghana [38]. The implementation of Cloud technology in healthcare has become the answer to enable healthcare organisations to enhance and increase relevant services for improved patient outcomes. Cloud computing is widely understood to provide a rich, effective and efficient environment for the provision of healthcare services and the ability to take the services to remote communities. Furthermore, researchers in Ghana reiterated the importance of Cloud computing as an ideal system that has the potential to facilitate patient's records to be collated, stored and managed in a timely and efficient manner [39]. In essence, this encourages the use of Cloud-based healthcare in remote clinics. Cloud computing is widely understood to provide a rich, effective and efficient environment for the provision of healthcare services and the ability to take the services to remote communities

Provision of Quality Healthcare Delivery for Patients: Cloud can help healthcare stakeholders not only to solve many of their existing problems but also to deliver quality healthcare services in a timely and cost effective fashion [40]. Researchers conducted by different authors indicate that Cloud computing is the easiest route to bridging the gap that exists between the urban and the rural healthcare services [41-43]. Pekka [44] contend that Cloud computing in healthcare can make healthcare consultation convenient for the patient. There are many examples of Cloud healthcare solutions that can be used in different contexts. There is substantial agreement in the research works that using Cloud computing permits doctors and patients access to information in an easier and more efficient way [45, 46]. The commonly known that Cloud-based healthcare can be used as a service used for the storage of personal health information on the part of health care providers and patients. Rolim *et al.* [47] pointed out that Cloud computing can fill the gap of providing quality healthcare to those areas that need suitable healthcare service most.

Collaboration among Healthcare Workers: Cloud technology provides a platform for collaboration among health works and different health sectors for efficient health care delivery to patients. This collaborative approach enables healthcare services to interoperate between them in order to offer a faster and efficient response helping to improve the patient quality of service through sharing information across healthcare organizations. Therefore, hospitals, clinics, imaging centers, pharmacies and insurance companies can efficiently share patient's medical records, prescription information, X rays, test results, physician's references, physicians availability, etc. that can be accessed anywhere and everywhere by authorized entities. All this information would be used for making decisions, obtaining better diagnosis and treatments to yield better results, scheduling physician's appointments and speeding insurance approval which highly improves patient's quality of service [48]. Sharma [49] placed Cloud healthcare at the center of healthcare collaboration work among healthcare sectors. In addition, this increases the ability to monitor the spread of infectious diseases and other disease outbreaks. Cloud Computing can also make Electronic Health Records (EHRs) and other clinical information systems affordable for smaller healthcare providers and for smaller organizational units that were previously uneconomic to support. In Scotland, for example, NHS Grampian hosts EHR computing services for the highly dispersed island populations of NHS Shetland and NHS Orkney [15]. These support the provision of stand-in physicians, remote clinics and emergency air response. In addition, the cost of scaling up capacity is lower for Cloud-based systems compared to traditional health IT business model.

General Health Education: Health education at mass level can help to prevent and control the diseases. Cloud services like PaaS and SaaS can be used to teach and train our masses about self-care. Web is a wealth of information for masses to know about fitness, health, dietary and sanitation issues etc. Majority of people get health related information from the internet using trusted resources like web pages, helper groups and blogs on particular disease type [50, 51]. Patients who already have suffered from a particular disease can share their knowledge, experience, dietary plan and medication process with new patients. Physicians and patients can know about the novel medication methods which are no yet widely in practice. However, these resources shouldn't be seen as an alternative of a physician [52].

Countries Deploying Cloud computing in HealthCare Management: We take a look at the examples of countries where cloud computing has been applied for healthcare management.

Iraq: Some efforts have been taken by the Ministry of Health in Iraq to deploy specific cloud models to promote health-related practices in different sectors. This includes re-engineering the way the patient and other health data are stored and thus allow healthcare professionals to access and interpret patients' conditions effectively [53]. Research indicates that hardware modularity, software modularity, cost effectiveness, network and training are some of the main environmental structure factors that influence the current utilization of cloud computing in the healthcare sector [54].

Ghana: According to Tegarden *et al*. [55] of the United States National Standards for information Technology (NIST), the application of Cloud computing plays very significant roles in healthcare delivery, maintaining health records, monitoring of patients, managing diseases and providing efficient patients' care. Furthermore, researchers in Ghana reiterated the importance of Cloud computing as an ideal system that has the potential to facilitate patient's records to be collated, stored and managed in a timely and efficient manner [56]. In essence, this encourages the use of Cloud-based healthcare in remote clinics. It also provides improvement in terms of healthcare service delivery and grant quick and timely access to health care resources to patients in Ghana [57].

Finland: Cloud based Kanta Personal Health Record (Kanta PHR) is a national data repository in which citizens may enter information on their health and wellbeing. The users can be citizens, professionals or both. The Kanta Patient Data Repository service offers citizens the opportunity of examining their medical records, easily and irrespective of time and place. It also supports health care delivery where patients seek treatment outside their place of residence. Prescriptions are processed easily in the electronic format as it is a safe method and information is kept secure. In Finland, all prescriptions and medicine dispensations are made electronically in the Kanta services. It also allows professionals to check patients' medication records and prevent possible adverse drug interactions and overlaps. In 2018, a total of 28.3 million prescriptions were issued, resulting in 64.4 million medicine dispensations [58].

Scotland: NHS Scotland, sometimes styled NHS Scotland, is the publicly funded healthcare system in Scotland. It operates 14 territorial NHS Boards across Scotland, seven special non-geographic health boards and NHS Health Scotland. As of 2016, emergency care patient summary is hosted in a national cloud data centre, comprising demographic, prescribing data and allergies for 99% of the Scottish population (approx. 5.5million). The system has reduced consultation times and improved patient safety in unscheduled and out-of-hours care, providing key information in emergency out-of-ours care environments and reducing errors [59].

Spain and Latin America: Salusport interactive online health community enables professionals from primary care centres to treat patients who suffer from chronic conditions, such as heart failure diabetes and hypertension. In the Valencia region, the use of this platform resulted in a 33% reduction of hospitalizations and a 50% reduction of primary care visits. Consequently, m Health has the potential to offer new and novel paradigms in health care delivery, which in turn can help Latin American HCS to cope with the new challenges they are facing [60, 61].

CONCLUSION

In conclusion, from the available literature, Cloud-based healthcare is presently the best model to manage data in different healthcare sectors as applicable in many health institutions [62-65]. The adoption of cloud based technologies is suitable for healthcare management. This is an indication that modern information technology is reaching out and can be used in the healthcare sector for the enhancement of medical services. Therefore encouraging the use of cloud technology for healthcare delivery and management is one way to improve the entire healthcare system.

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